Loaded Q Calculations for the ESS Medium Beta Linac

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Introduction

The purpose of this note is to set the loaded Q value for the 6 cell medium beta cavities. The lattice data is from the OPTIMUS lattice released on 26-July-2013. The beam current assumed is 62.5 mA. This note uses the formulation described in the note "Loaded Q Calculations for the ESS Superconducting RF Linac", ESS Docs Document 295.[1]

Lattice Parameters

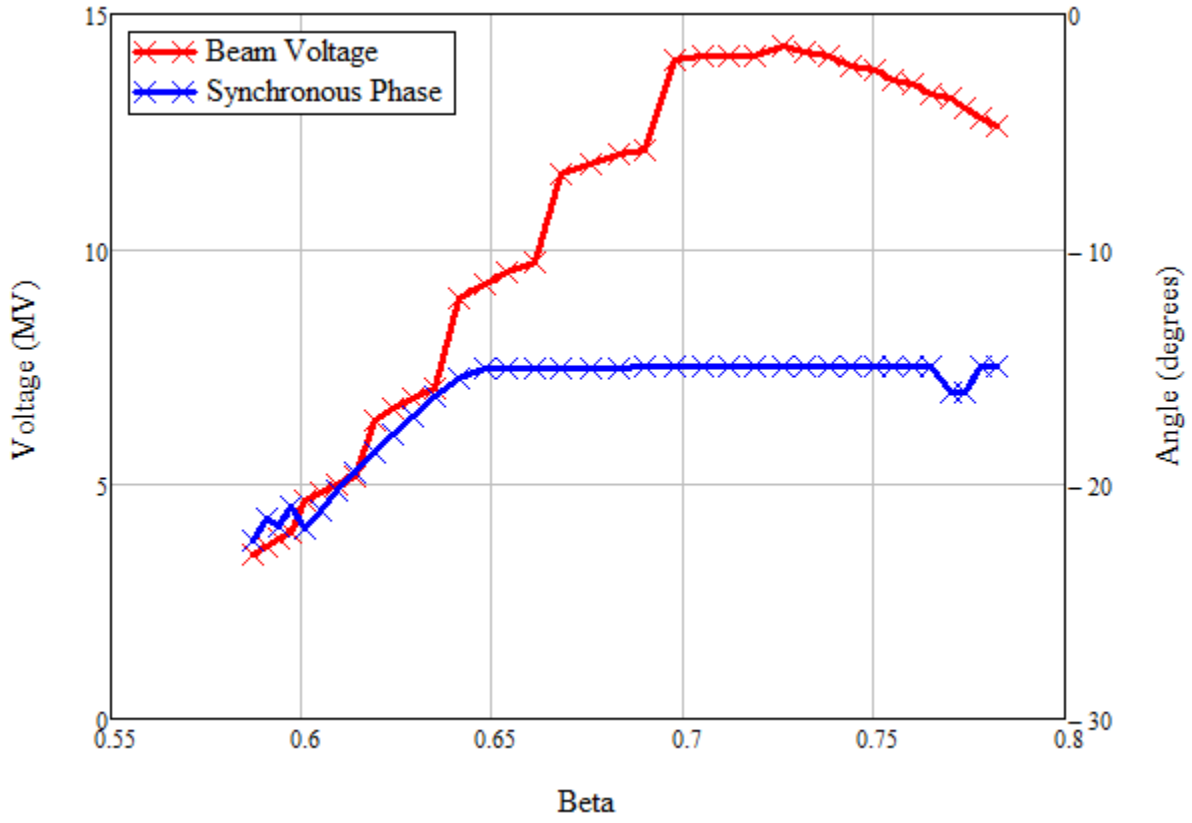

Figure 1. Beam Voltage and Synchronous Phase for the Medium Beta Section of the ESS OPTIMUS Lattice.

[1] "Loaded Q Calculations for the ESS Superconducting RF Linac", http://eval.esss.lu.se/cgi-bin/public/DocDB/ShowDocument?docid=295, Dave McGinnis

Field Map

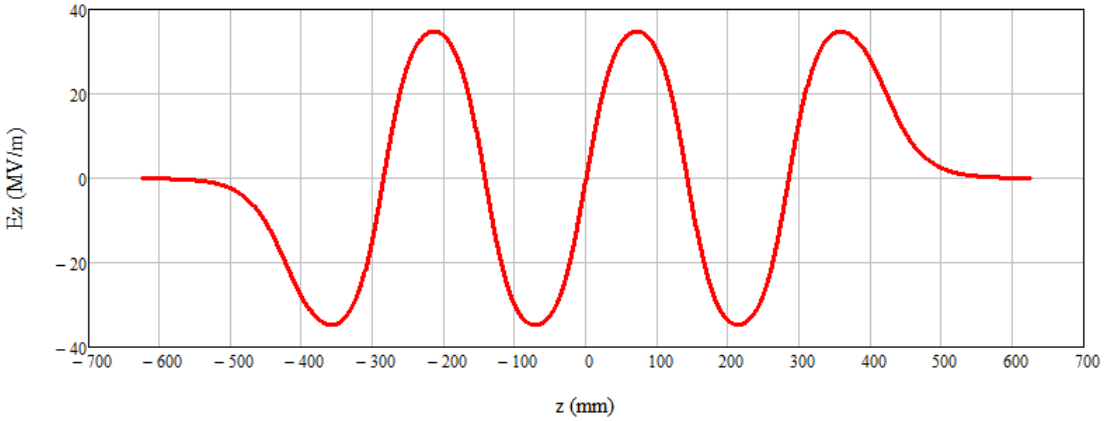

Figure 2. Six cell medium beta field profile with β_g=0.67, a peak surface field of 44 MV/meter, and a stored energy of 144 J.

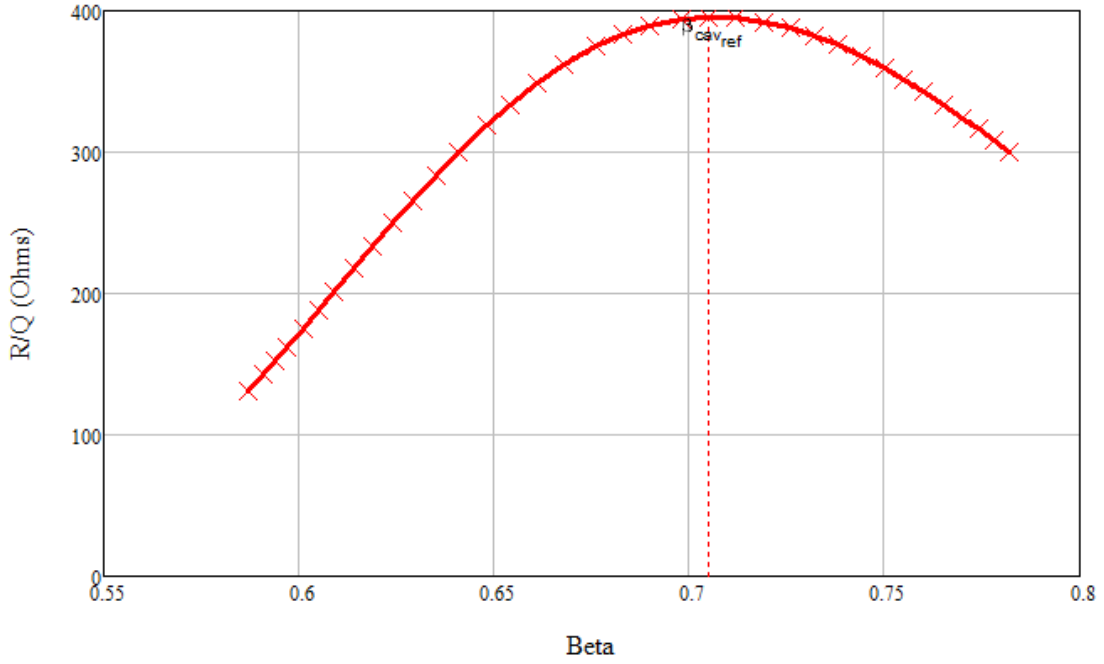

Figure 3. R/Q plot for the 6 cell Medium Beta Cavities. The maximum acceleration R/Q of 395 Ohms occurs at a β of 0.705 for cavity 22(second cavity in the fifth cryomodule)

Optimum Loaded Q

For minimum reflected power of the entire medium beta section, the Q_L was set by the operating point of the second cavity in the fifth cryomodule. At this operating point, β=0.705, the accelerating R/Q was 395 Ohms and the Q_L is $590x10^3$. The forward and reflected power for this value of Q_L is shown in Figure 4.

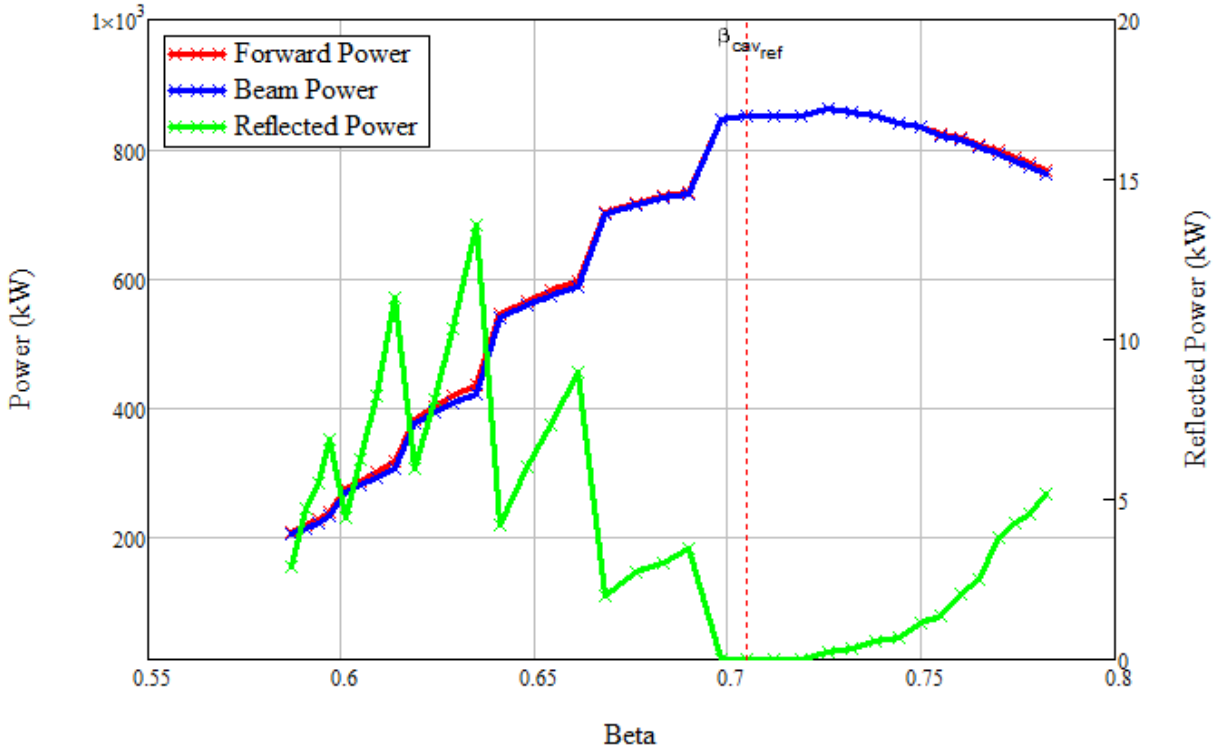

Figure 4. Forward and reflected power for the Medium Beta cavities with a Q_L of 590x10^3. The Q_L was chosen for the operating point of β=0.705 and a beam current of 62.5 mA.

Required Power as a function of Loaded Q

The optimum loaded Q value of 590,000 might require the coupler probe penetration to be deeper into the beam pipe aperture than is comfortable. In this section, the forward and reflected power as a function of loaded Q was examined and the results are shown in Figures 5-8. It was found at β=0.705, a Q_L of 700,000 requires 0.7% more power and Q_L of 800,000 requires 2% more power than the power required with Q_L of 600,000. At β=0.635, a Q_L of 600,000 reflects 15 kW (peak), a Q_L of 700,000 reflects 30 kW and a Q_L of 800,000 reflects 47 kW.

Conclusions

The desired loaded Q for the 6 cell medium beta cavities at 62.5 mA of beam current for the OPTIMUS lattice is 590,000. However, a loaded Q of 800,000 would require an insignificant amount of more forward power and the increased reflected power is well with the range of the klystron circulators.

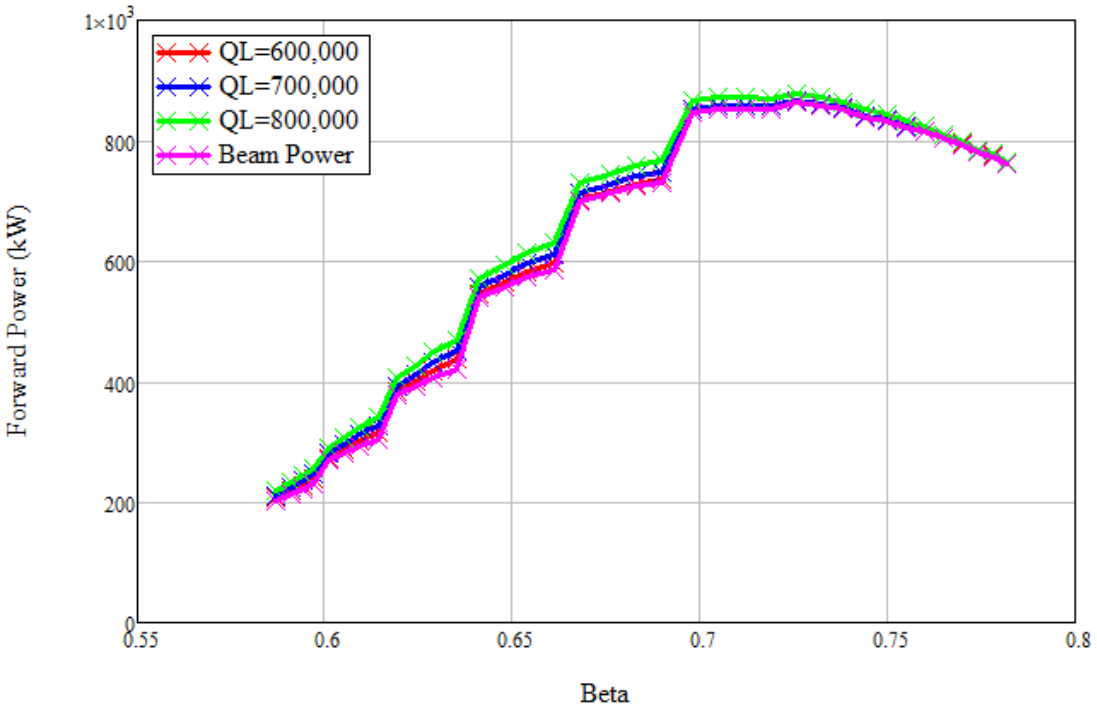

Figure 5. Required peak forward power as a function of loaded Q (Q_L). At β=0.705, a Q_L of 700,000 requires 0.7% more power and Q_L of 800,000 requires 2% more power than the power required with Q_L of 600,000.

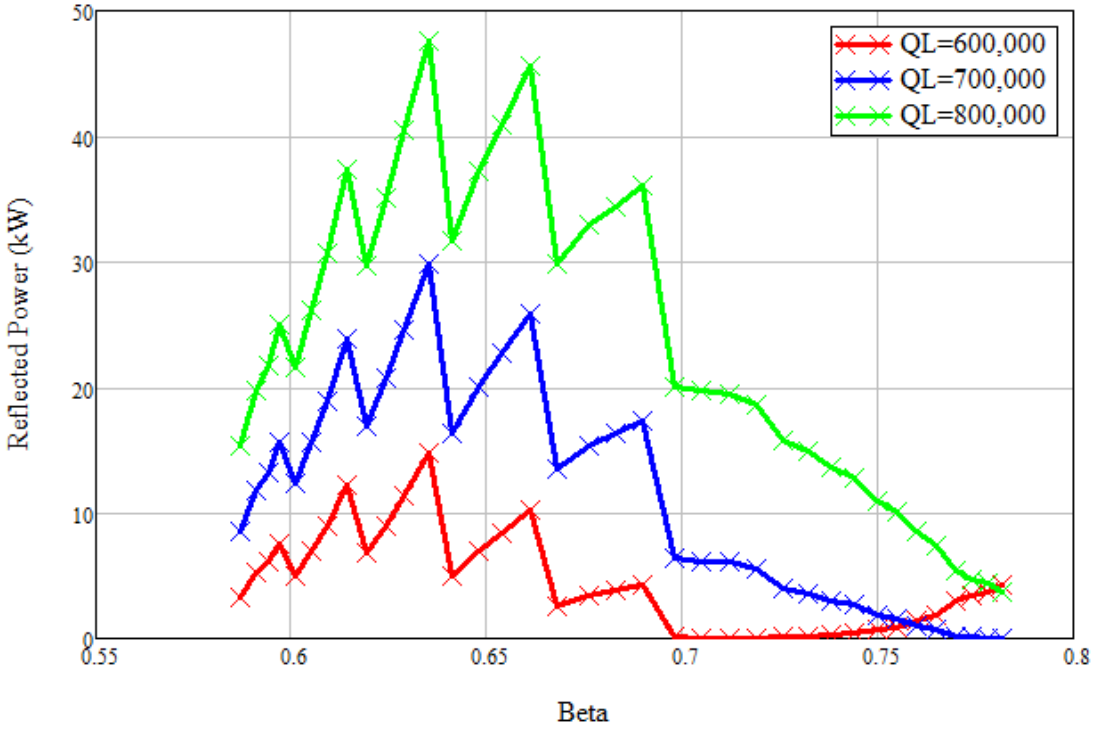

Figure 6. Reflected power as a function of loaded Q (Q_L).

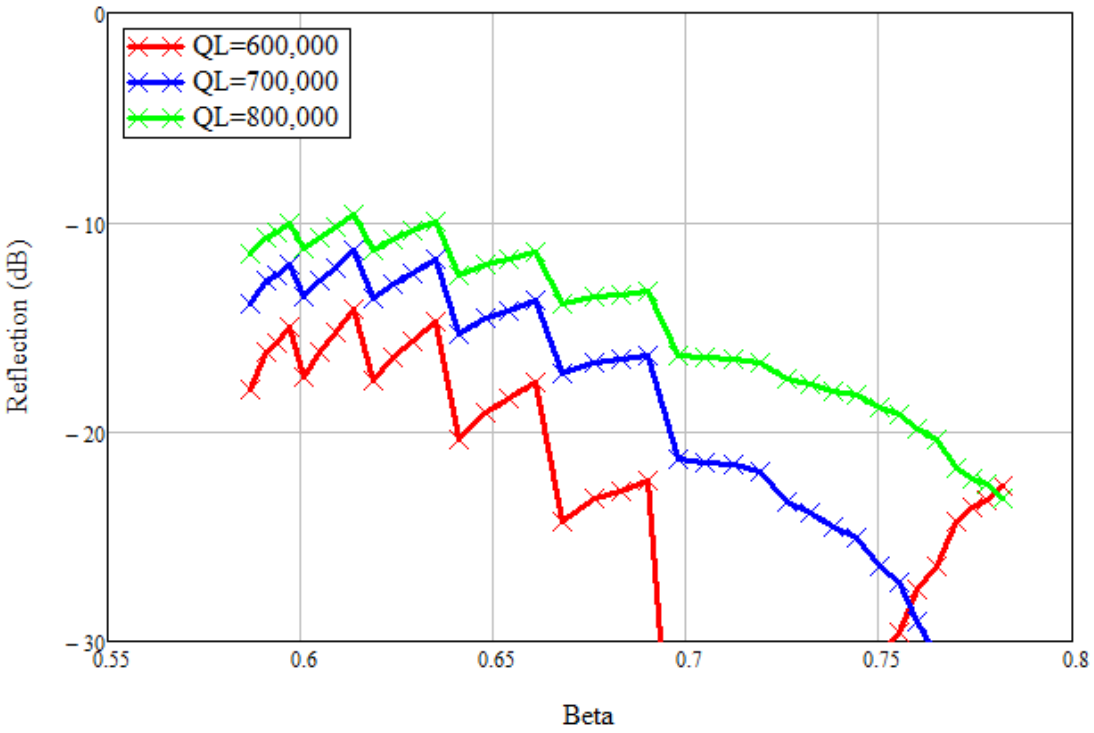

Figure 7. Reflection Coefficient as a function of loaded Q (Q_L).

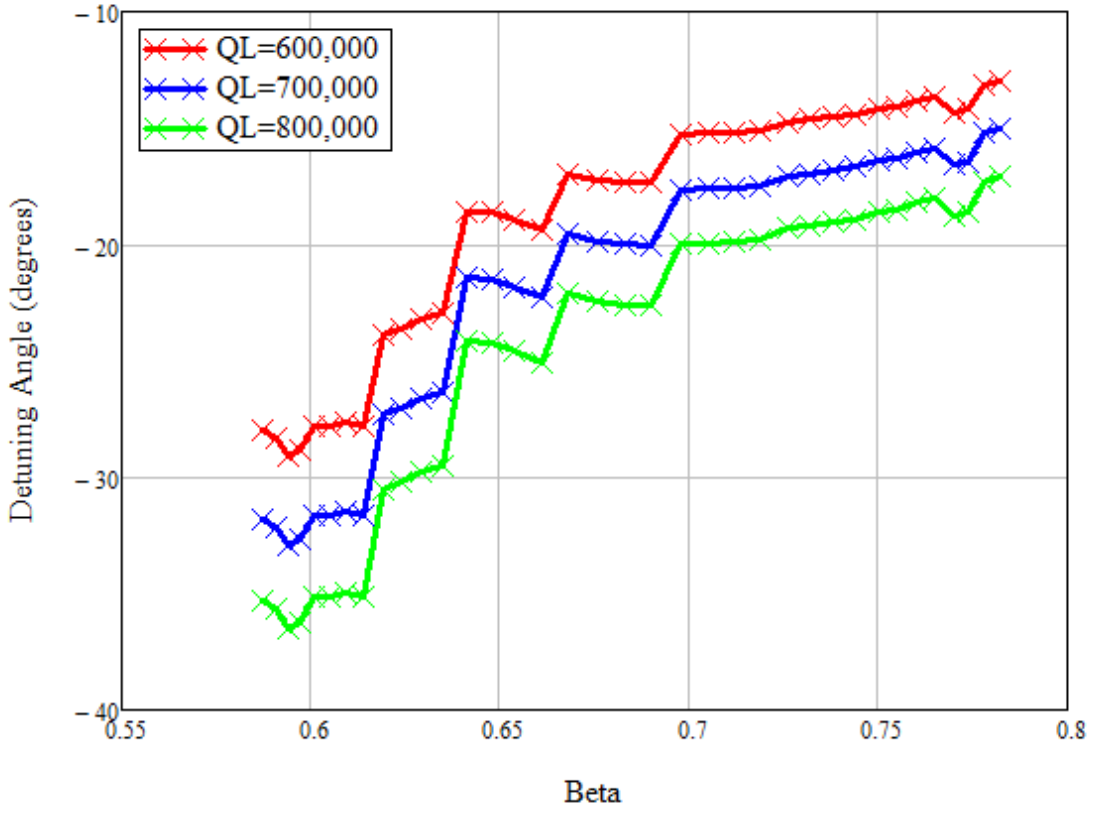

Figure 8. Required cavity detuning angle as a function of loaded Q (Q_L).